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Effectively clean air fan coolers with water and steam

In many refineries and petrochemical plants, air fan coolers (AFCs) become a major bottleneck to increasing plant capacity. Many plants suffer from lower heat duty than designed, especially during the summer months, which can lead to lower plant capacity. New AFCs should be constructed to solve this problem, but investment costs are high and most plants do not have enough space for new AFC installation. These factors make it difficult to construct a new AFC.

In general, efficiency reduction of AFC is due to foreign substances on the surface of the finned tubes. These substances are formed over 3 yr–4 yr of consecutive operation. The foreign substances slowly stick to the tube surface over years (**FIG. 1**).

Foreign substances interfere with effective heat transfer of AFC tube surfaces and make the space between the tubes narrow, blocking airflow. Finally, the heat duty may become lower than the design condition.

The challenge of cleaning AFC tubes.

Effective cleaning can solve the problem fundamentally, without the construction of a new AFC. Cleaning of the inside of the tubes is sometimes performed, but this does not result in significant improvement.

The authors have devised two new cleaning techniques and equipment solutions for tube external surface cleaning (**FIG. 2** and **TABLE 1**). These cleaning techniques can effectively remove foreign substances on the tube surface and improve efficiency.

The first cleaning method utilizes the steam under the AFC tube bundle. It is a manual operation in which a worker performs cleaning with a nozzle. The equipment is specifically designed to spray the steam with the condensate water developed by SK Energy. Since the cleaning is performed from the lower part of the AFC, the cleaning will be effective at the lower part of the tube.

The second cleaning method involves spraying high-pressure water at the top of the bundle, using a commercially available machine. Prior to cleaning, the louver must be removed and the cleaning rail must be installed (**FIG. 3**). Each cleaning method addresses a different area of the AFC, so both cleaning methods must be applied for effective cleaning. Both may be carried out during operation.

To clean an AFC tube outside, the operation team selected an AFC with a

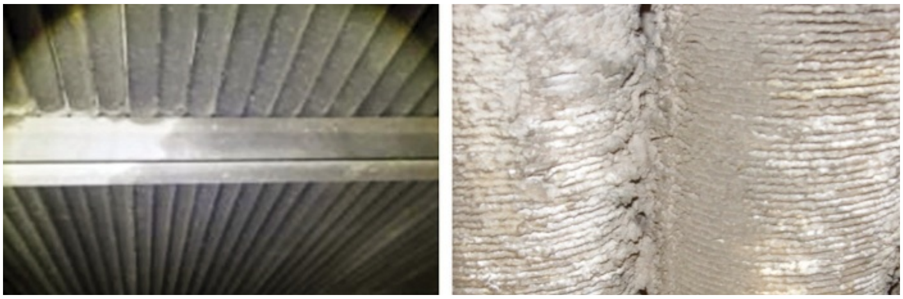


FIG. 1. Finned tube condition after 3 yr of operation.

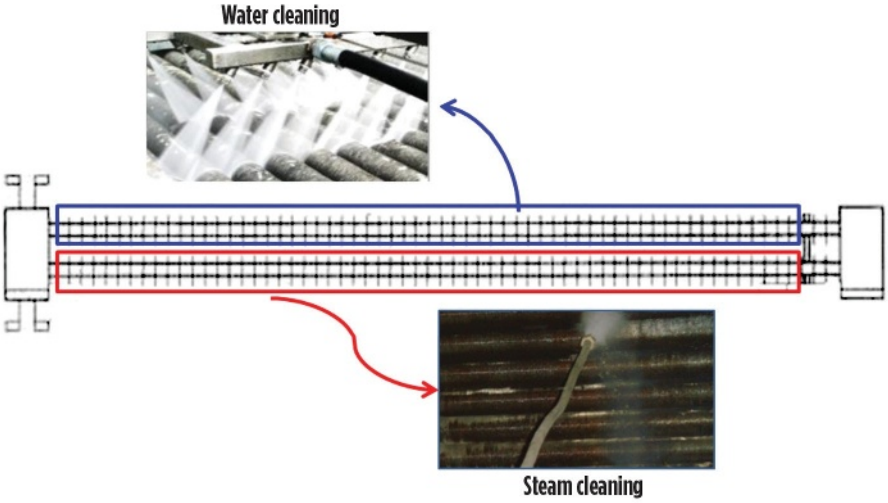


FIG. 2. Diagram of two AFC cleaning methods.

lack of capacity (27 items, 150 bundles). Cleaning was performed sequentially—water cleaning first, followed by steam cleaning.

Fans must be stopped individually for cleaning. In this instance, it took approximately 7 d to clean 10 bundles. Demineralized water was used to avoid corrosion of the surrounding equipment.

TABLE 1. AFC tube cleaning method

Item	Steam cleaning	Water cleaning
Cleaning media	Low-pressure steam (w/condensate)	Demineralized water (90 bar–350 bar)
Cleaning tube	Lower 2–3 tubes	Upper 2–3 tubes
Duration	3–4 bundles/d	2–3 bundles/d

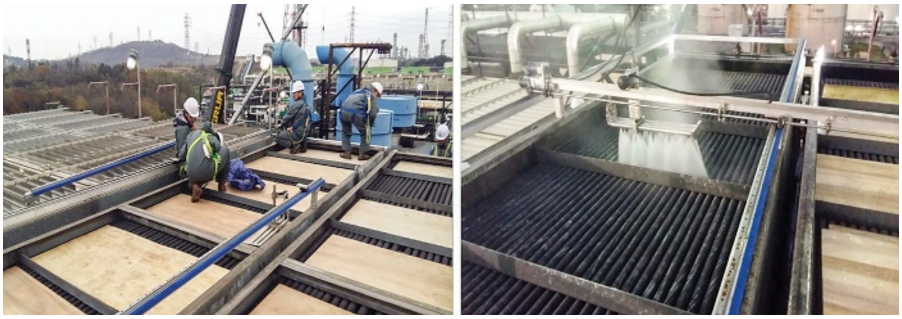


FIG. 3. Rail installation and cleaning.

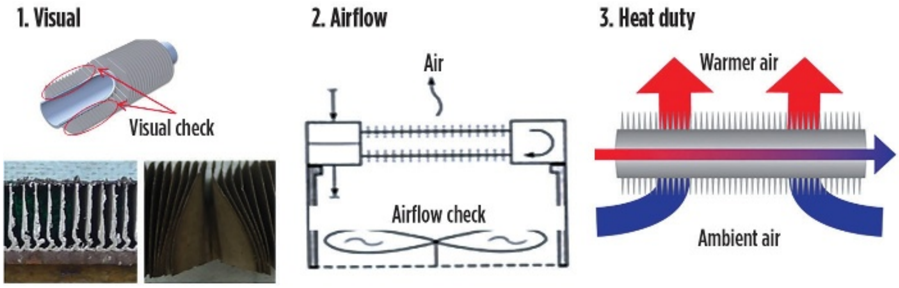
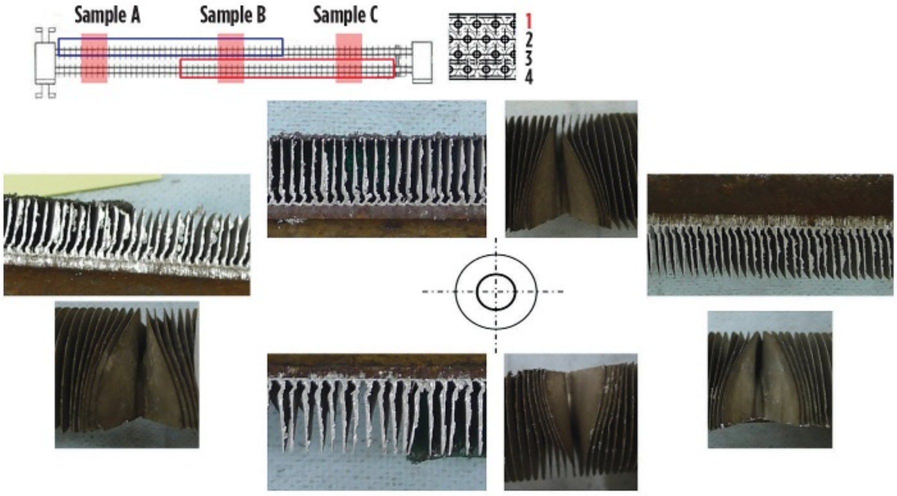


FIG. 4. Items to be checked after cleaning.



Sample A: Cleaned with water jet (upper tubes)
Sample B: Cleaned with steam and water jet (upper and lower tubes)
Sample C: Cleaned with steam (lower tubes)

FIG. 5. Sample cross-section of tube (Sample A area, first row).

Wastewater from cleaning is collected at the bottom through the tent. During cleaning, the status of the operation can be monitored by observing the condition of the wastewater. At the beginning of cleaning, a significant amount of foreign matter (e.g., mud) will be seen. Even insects and dead birds may be flushed out during cleaning. As the operation progresses, the wastewater turns clear.

Cleaning results. To check if the cleaning was effective, the three items outlined in **FIG. 4** should be ascertained. After examining the appearance of the AFC with the naked eye immediately after cleaning, it can appear that foreign material has been sufficiently removed and cleaned.

To more closely examine the cleaning status of the tube, a tube in the bundle can be cut to observe a cross-section (**FIG. 5**). To confirm each cleaning effect separately, sections of the bundle were divided in the case discussed. Only water cleaning was carried out on the blue part, while the red part received only steam cleaning.

A total of 12 tubes were examined by cutting four tubes of each A/B/C area, and the cross-sections were checked to see how much foreign material had been removed, according to the cleaning method and tube position.

As expected, steam cleaning successfully cleaned the bottom portion of the AFC, and water jet cleaning took care of the top. Therefore, it has been determined that both methods must be applied for effective cleaning.

Next, the change in airflow before and after cleaning was analyzed. The airflow was measured for a total of five points before cleaning, and the airflow of the fan was calculated by calculating the average.

The airflow was also measured after cleaning to see how much it had increased from the actual and design airflow rates prior to cleaning. When the airflow rate before cleaning was less than 90% (ratio of actual to design condition), the increase was found to be 13%–19%—a significant cleaning effect. Conversely, an AFC with an airflow rate of more than 90% showed an increase of only 9%. Overall, cleaning increased the total AFC airflow by 14%.

Next, to check the change in heat duty, the difference in heat duty before and after cleaning was examined. An AFC with a low heat duty of less than 60% before cleaning showed a high heat duty increase of 14%. The higher the heat duty before cleaning, the lower the increase in the heat duty rate. An AFC with a high heat duty of more than 90% showed little change in heat duty. Overall, heat duty compared to design increased by 11%.

The airflow was increased by facilitating heat exchange between the tube and air as foreign substances were removed. At the same time, airflow was increased by widening the gap between the tubes. In other words, the increases in airflow and heat duty are correlated.

As per the cost analysis results, the amount of effect from the increase in capacity and charge due to cleaning is expected to be $2.6 MM, vs. a cleaning cost of $500,000. Therefore, the capacity of the plant was recovered without installing a new AFC. With increased productivity, the plant is expected to measure a return on investment of more than $2 MM.

Recommendations. After 1 yr of testing, several important points can be summarized.

The AFC top (water) and bottom (steam) cleaning methods have independent cleaning effects. Therefore, both top and bottom cleaning should be applied to maximize the cleaning effect.

AFC tube cleaning can be carried out during normal operation. Fans should be turned off for AFC bays being cleaned. Cleaning should be carried out at a time when it will not affect capacity, even if only one fan is turned off. In general, cleaning is recommended in winter, when temperatures are low and there is room for extra AFC capacity.

Post cleaning, the AFC should be monitored to see how long the cleaning effect lasts. After a certain period of time, the cleaning effect is lost. Therefore, air flow or heat duty should be measured and checked. Then, the items to be cleaned should be selected. As the existing efficiency is higher, the cleaning effect decreases. In the case of an efficiency of greater than 90%, a very low effect is observed from cleaning.

As plant maintenance cycles are extended, the efficiency of the AFC can decrease. In this case, cleaning of the AFC is a good example of efficiently maintaining the capacity of the plant without spending a large amount of money.

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